THE NATIONAL ACADEMIES
CENTER FOR EDUCATION
BOARD ON SCIENCE EDUCATION

THE STATUS OF RESEARCH ON LEARNING SCIENCE
WITHIN INFORMAL EDUCATION SETTINGS

THINK PIECES

Public awareness of science and informal learning – a perspective on the role of science museums

Susan Stocklmayer
National Centre for the Public Awareness of Science
The Australian National University

In the past fifteen years, much has been written about the communication between science and the public. Any analysis of the role of informal or free choice learning, especially that experienced through science museums, zoos, aquaria and the like, must first ask what the *goals* of science communication with the public might be.

For many years, the goals of "Public Understanding of Science" (see Appendix) have led to a plethora of offerings of science programs, courses, field trips and so on to provide interested adults and children with ways to broaden their science knowledge. This paper is not concerned with those aspects of science museum outreach, because improvement to such programs is relatively easily attainable by applying the well-established principles of good teaching and learning. These include attention to constructivism, multiple intelligences, learning styles, and so on. Rather, it is concerned with those aspects of informal learning which result from more casual encounters with science in a museum setting.

At present there is a tension between the original goals of the Public Understanding movement and a broader view of science communication. My own view is that there exist at this time essentially two kinds of science communication: the first is "promotion of science' and the second is "dialogue" or "knowledge sharing". Informal learning generally has been concerned with the former, in part because external factors have supported this focus on acquisition of science knowledge.

Promotion of science

In this context, much attention is being paid to the current offerings of museums, zoos, and other institutions. Indeed one of the 'position papers' for the 4th World Congress of Science Centres states

> *It is ironic indeed that in a world facing a myriad of gravely important issues, many of them grounded in science and technology, many science centers focus almost exclusively on making science fun and exciting, playgrounds for the mind…. children do have a wonderful time at science centers, and engaging children in science is a truly worthwhile goal. But children are not the only people in our society who need to understand science. And by over-emphasizing fun, we run the risk of literally losing the science in science centers. For a variety of reasons, it is important for science centers to expand their programs to include adult audiences* (Mintz, 2005).

How to do this is not well understood, but nor is how to pull in the disaffected teens, the disadvantaged minorities, the older retired groups…. the list of those who do *not* come is endless. I wonder, however, whether we are clear about *why* we want these visitors – what goal do we have in mind in emphasising the need to attract them to the museum? For Mintz, at least, the goal is to inform:

> *Because our world is profoundly shaped by science, the corollary assumption is that everyone needs to understand science. Unarguably, many science-related topics have public policy implications. A democratic form of government is predicated on the existence of wellinformed electorate, capable of participating in the decisions set before it, and the data show that the American public is not well-informed about science and technology. This creates both a challenge and an opportunity for science centers (Mintz, 2005)*

Let us assume for the moment that we accept the goal of promotion of 'science for all'. What, then, is the process by which informal learning occurs? We believe that there are two main reasons why adults seek scientific knowledge and understanding: because they are interested or because they have a need to know.

Science centres and similar institutions work on the premise that visitors *are* intrinsically interested. They provide experiences that are, indeed, "fun" – because that is why people come to visit. They *should* be 'playgrounds for the mind'. In Questacon, for example, it is common to find tourists who have come simply as part of an organised bus trip, having a wonderful time and spending hours with the exhibits. The power of this experience should not be underestimated. And the participants in these activities do, without doubt, learn.

An Ad Hoc Committee of the National Association of Research in Science Teaching (NARST) stated in 2003 that there are three "important characteristics of learning… First, learning is a personal process, second, it is contextualized, and third, it takes time… Learning occurs when people reconstruct meaning and understanding; a different way of thinking, perhaps, or a different way of responding to an idea or event. Learning that occurs today depends on yesterday's learning and is the foundation for tomorrow's learning. The cumulative, iterative process of learning emphasizes the importance of time." (Rennie, in press). Our own research in this area reinforces the importance of iteration.

The issue of contextualization, in both personal and social contexts, is critical. It has been well described elsewhere and I will not dwell on it here except to say that continuing research from eminent people in the field such as Hein, Falk, Dierking and Rennie increasingly illuminates this aspect of the experience. Expecting members of the public to make immediate and direct links with the target science, however, *without* providing personal experiences - as the 'Public Understanding' movement would have us do - is unreasonable and unrealistic. All the evidence indicates that they will not become engaged at all. Further, the idea that an experience is "just fun", which is so often denigrated by those in the PUS domain can, in fact, have powerful consequences if it leads to subsequent positive experiences or to the re-evaluation of prior experiences. Rennie (in press) has stated that there are three myths about learning in science museums which have been thoroughly debunked by recent research. These are that "playing and learning cannot occur at the same time", that "if learning occurs, it must happen at the museum" and that "what people learn is predictable and therefore easily measurable".

For science centres, festivals, television documentaries, popular books – indeed all the modes of communication about science which are available to the public - the message is simple. The *experience* is everything. Appealing design, strong personal contextualisation and readily evident links to the target provide the best chance for a successful and satisfying interaction which results in enhanced scientific understanding.

To summarise: learning rarely, if ever, occurs and develops from a single experience. It is cumulative, emerging through diverse experiences. It is a dynamic, never-ending, and holistic

phenomenon of constructing personal meaning. Much of what people come to know about the world, including the world of science content and process, derives from real world experiences within a diversity of appropriate physical and social contexts, motivated by an intrinsic desire to learn. For those concerned with conveying a scientific 'message', whether it is formally presented in a science centre or as part of a public campaign, the *engagement* of the individual is the key. After that is achieved, positive outcomes may follow, sooner or later. 'Science for all' must be motivated from within.

How can science centres engage more adults?

The question now arises as to whether, as argued by Mintz (2005), the appeal of current science centre offerings is appropriate to draw in adult visitors. Science centre demographics would argue otherwise and many centres are seeking ways to change this. Perhaps, it is argued, a different kind of exhibition might bring the adults through the door - a more thoughtful, issue-based, controversial kind of exhibition. I will not seek to debate this here, only to say that there is little evidence that this will engage substantial numbers of those who presently do not visit. Science centres, science lectures and talks, zoos, aquaria, art galleries and historical museums mostly attract the 'converted'. A different kind of exhibition might, nevertheless, provide a more satisfying visitor experience for adults and this would be beneficial. I am wary of those, however, who argue for exhibitions seeking to effect behavioural change regarding the environment, biotechnology, and so on, if they do not seek to be "fun" as well. People come to a science centre to have a good time – why would they otherwise spend so much time there?

How might we modify the offerings of science centres to take these ideas into account? A quick sideways glance at the explosion of publishing in the arena of popular science books provides some clues as to what intrigues and excites adult readers. Meyer (2005) says that in the first place, popular science books have a strong *narrative*. We know that learning takes place when a context is linked to a narrative in the life of an individual or in the lives of others. Second, the narrative is written in relatively simple language, and features individuals in a personal and interesting way. For any individual, there is a natural tendency to seek continuity across their experiences in any aspect of their life by constructing a series of narratives that link these experiences together. Stories from the lives of others, for example from the history of science, can readily engage the attention of an audience.

Designers of exhibits have, of late, paid much attention to the recommendations of constructivism, whose principles now guide every formal science syllabus. These principles dictate that classroom science must be relevant to the learner, building on existing ideas and taking into account cultural issues. In the informal sector, however, the translation of this principle is the "contextual exhibition", in which exhibits *explicitly* deal with the phenomena in question. I have deep reservations about this path, in that much of our research has indicated that those visitors who are "playing" with a more decontextualised exhibit may well be making personal connections which are very powerful. A narrative is being constructed by the visitor, which is developed in subsequent experiences. I believe that if an exhibit is too contextualised, it provides for limited connections and may impede broader meaning-making.

In the everyday world there may be occasions when individuals choose to engage with scientific experiences because of an immediate need. This may, for example, be in response to a medical need or to a local environmental problem. It is uncommon, however, for such engagement to be sought in a science centre, and this is an issue for consideration. How much are these aspects reflected in the offerings of a science centre? Can the public explore, get some sense of science in a broad domain, and readily access information? Science centres are all about promoting science, but to what end? One can debate this for a long time, but I wish to move now to the point made earlier about "knowledge sharing".

Dialogue and knowledge sharing

"Dialogue" is the current buzz-word, and is attracting considerable interest. The implications of this new approach to public awareness of science are far reaching, and may be problematic for science centres. Dialogue implies first that it is imperative for scientists to engage the public on equal terms, not as keepers of knowledge on one side and learners on the other. Second, it is not only public *opinion* which has a place in this interaction, but public *knowledge*. Increasingly, indigenous and local knowledge is seen to be important to this process. Respect for such knowledge is critical. With extraordinary speed, the tone of debate in Europe has changed to one of openness and accountability. There is a new emphasis on strategies such as focus groups, consensus meetings, and so on, to probe public opinions of important current issues. In the area of informal learning, some museums are becoming less focused on transmission of content. Instead, they are setting what might be called "learning agendas", which recognise and take into account the many different ways in which learning can occur. Yet decisions about the goals of informal learning, for the many people whom these areas aim to reach, are no closer to resolution than before.

Fundamental to progress, we believe, is a much deeper research agenda to understand how to make the most of occasions where the world of science interacts with the public and to understand the diverse and multicultural groups that constitute our adult populations: how to reach them, how to listen to them and how to make science accessible to them, should they desire it. To conduct such research without any idea of the ultimate goals, however, is futile.

Implementing a research agenda

The museum sector has to some extent addressed evaluation of their activities, through an established body of research dating back to the 1960s. Other sectors such as festivals, the media and so on are very far behind. The research needed in this area is challenging. We know very little about what is interesting or useful to the public (recognising, of course, that the public is both heterogeneous and diverse), and we do not know how to reach the people who are "unengaged". Little is known about how much science and technology is learned from television, from the internet, and from books.

In the museum domain we know more, but it concerns visitors who participate purposefully. We know that adults visiting science and technology museums, even when they profess little or no previous science education, are intrigued and entertained by the visitor experience. We know that the links they make to their own past experiences are critical to this enjoyment and underpin all kinds of learning. We know that complex explanations, difficult instructions or very high-tech exhibits inhibit their involvement. For this group, the learning is often different from the intent of the exhibit designer but nonetheless meaningful. Highly contextual exhibits may be useful in some instances, but inhibiting in others.

The results of research, however, are often slow to be implemented. Researchers themselves are often employed by the organisation concerned and results may be confidential. Small but important changes go unreported in the wider community. In this paper, I was asked to comment on the process by which research findings are carried out in practice and my short answer is "very slowly". Key researchers have had a large influence because they have worked to publicise their findings more widely but even then, results trickle down. This is directly comparable to the formal education sector, where individual school participation may result in change but, overall, many years elapse before research implementation becomes the norm. Using the formal sector as a model, however, there is one other way to achieve results and that is by top-down curricular reform. The rapid and unsettling changes that result from ever-changing curricular initiatives would sound warning bells for any comparable movement in the museum sector but useful gains might be made if gatherings

such as the World Science Centre Congress made a serious and concerted effort to include recent research on the plenary agenda. It is my observation that parallel sessions at such conferences are heavily weighted towards "practice" rather than "theory" and that research sessions are not well attended. It is hard to be heard.

Setting a research agenda

"Recognizing that learning is personal, contextualized, and takes time, provides a framework for interpreting the research findings we have and providing directions for the future... Research in [informal] settings is difficult because of the free-choice nature of the learning experience and the need to retain its context. This makes it difficult to generalize research results to other contexts and settings, and in many areas research is sparse and will probably remain so for some time" (Rennie, 2005). An agenda was set by NARST in 2003, to pursue six areas identified as important to contextual learning. First, to understand the nature of initial engagement. Next, the physical and social contexts need to be better understood. The iterative and cumulative nature of learning is important to understand, as are its processes. "Finally, innovative approaches are needed to expand the range of methods and analyses used in research" (Rennie, 2005).

If there *is* a body of scientific knowledge that is desirable for people to have, it is relatively easy to proffer experiences around this knowledge through the outreach of museums and science festivals. To reach people who do not avail themselves of this outreach is a problem not well understood.

There is still an emphasis in the public arena on talking to the converted, with some attention recently to talking with the concerned. A gulf will remain, however, unless scientists are brought into the discussion as players, not captains in the debate. There is as yet no explicit recognition of the *public's* knowledge being of value to scientists. Might a *truly* literate citizen be one who, no matter what their scientific understandings, recognises the uniqueness of knowledge and respects an individual's ability to contribute to those understandings? This recognition would therefore accord to everyone the probability of being a scientifically literate citizen, and places the responsibility for achieving some measure of literacy within the domain of individual experience, for scientists no less than lay people. Thus literacy lies not in aspiring to a body of knowledge, but in recognising the many faces of science and the public contribution which can be respected, included and celebrated

Another key question, however, has not (as far as I am aware) been addressed in any research to date. This is the issue of what the public *wants* to know. "Public understanding" implies that the science knowledge is there, waiting for the public to join in. We suggest, however, that the more profitable process in the longer term will be to find out what is needed, where, and by whom. We do not underestimate its difficulty. But if science and technology are to engage the public, we need to understand what individuals within the community, in all their diversity of environments and occupations, would like to know.

Our own vision for the public's relationship with science is outlined below, together with the implications for science centres and the research that needs to be done to achieve these outcomes. Ideally, the public would comprise:

- People who feel that science and technology lie within their interest and their personal lives. *For science centres this means understanding how to promote relevant, constructivist science with ample opportunities for "remindings" and for play.*

- People who feel that the nation's science is both their property and their responsibility. *For science centres: How to represent the narrative history and tradition of a country's science, including gender and cultural perspectives?*

- People who are able to access new knowledge in science and technology and understand

how it will affect their lives. *For science centres this means finding ways to facilitate information access. There should be presentations of recent developments, in a relevant and open manner, with respect for dialogue and opinion. Ethical, cultural and social implications should be honestly and openly acknowledged.*

• People who feel comfortable about processing relevant scientific information so that their personal areas of interest are well served. *For science centres: What are the personal areas of interest that will be well served?*

• People who feel that their own knowledge and concerns are valued by the scientific community. *For science centres:Local and indigenous knowledge and understandings should have high status. Science must be seen to be responsive and respectful.*

These are demanding goals. Nevertheless, to focus simply on science promotion is to tread the same path we have walked for the past forty years. We now know that most of our public is on a different road.

A note about references

The text above is a synthesis of current thinking in our Centre. It has extensively drawn on the following papers, and the literature summarised within these papers. They are available if required. Relevant references are not listed separately within the body of the text, except where direct quotes have been made.

Stocklmayer, S.M., Gore, M.M., & Bryant, C. (Eds). (2001) *Science communication in theory and practice*. Dordrecht: Kluwer

Stocklmayer,S., & Gilbert,J.K. (2002). Informal chemical education. In J.K.Gilbert, O. De Jong, R. Justi, D.F. Treagust, J.H. Van Driel (eds.). *Chemical Education Towards Research-based Practice*.Dordrecht: Kluwer (pp. 143-164)

Stocklmayer, S.M., & Gilbert, J.K. (2002). New experiences and old knowledge: towards a model for the public awareness of science. *International Journal of Science Education, 24,* 835-858.

Rennie, L.J.& Stocklmayer, S.M. (2003). The Communication of Science and Technology: Past, Present and Future Agendas. *International Journal of Science Education, 25*, 759-773

Burns, T.W. O'Connor, D.J., & Stocklmayer, S.M (2003). Science Communication: a contemporary definition. *Public Understanding of Science, 12*, 183-202

The following additional references are mentioned in the text:

Meyer, A. (2005). The fairy tales of science. A study of popular science books. A thesis currently submitted for the degree of Doctor of Philosophy of The Australian National University

Mintz, A. (2005, April). Science, society and science centers. A provocative paper for the 4th Science Center World Congress.

Rennie, L.J.(in press). Learning science outside of school. In S.K.Abell & N.G.Lederman (Eds). *Handbook of Research on Science Education*. Mahwah, N.J. Lawrence Erlbaum Associates.

APPENDIX: BACKGROUND TO THIS PAPER

In Europe and the United States, the idea of "Science for all" has generally been framed in terms of "science literacy", which is assumed to describe a level of knowledge and understanding of science facts and processes. Arguments for science literacy have been made by many authors over the past twenty years, in terms usually similar to the following:

- The *economic argument* which points to the importance of science and technology in industrial wealth creation. This is the argument which carries most weight with governments.
- The *utility argument* which suggests that scientific knowledge is necessary for coping with aspects of modern life.
- The *democratic argument* which reasons that an understanding of science is necessary in order to participate effectively in modern democratic processes.
- The *social argument* which states that those who benefit from public research funding should be accountable to that public and explain what they re about.
- The *cultural argument* which asserts that science is a major human achievement and as much a part of culture as art and music

Even if one agrees that such knowledge and understanding is necessary, there are major practical problems in achieving these goals.

It is important to note that the arguments imply that the responsibility rests with the public to learn and understand science. Their fundamental underlying principle is a vision of "Public understanding of science" which implies acquisition of a body of knowledge called "science", unbounded and universal but already known and understood by a group of privileged "scientists". This 'deficit model' of the public has increasingly been criticised of late, particularly in the UK but also in countries such as the USA and Australia. A natural extension of this principle, however, is that institutions such as science centres have a corresponding responsibility to educate the public. "Lifelong learning" must be provided for.

A note on acquisition of scientific knowledge

The communication of science and technology is assisted by the media, which acts as a source of information as well as the mode by which it is transferred. It is now the most influential avenue for informal education about science and technology. One might easily imagine that we have the best-educated population in terms of science and technology that the world has ever had. But have we? The answer depends on what such a question really means. Mintz (2005) gives some figures for the United States:

> "Less than 15% of the public considers itself to be very well informed about new developments in science and technology, and 30% defines itself as poorly informed. In general, people consider themselves to be less well-informed than they used to be… [but] The percentage of Americans that could correctly define DNA increased from 45% in 2001 to 60% in 2003, and a majority of Americans now know that antibiotics are not effective against viruses. These data confirm that the public is correct in its belief that it is not well informed about science and technology."

We have been conducting workshops in science communication for scientists for the past ten years, reaching close to 500 researchers from a wide variety of disciplines. We have collected results from their completion of sections of a science questionnaire first delivered to the general public in the UK and USA in 1988. We have found that, generally, the results indicate a higher level of knowledge amongst the scientists than in the general population described in the paper, as one might expect. Nevertheless, there is no single question on which the scientists as a group have scored 100%, even such questions as whether table salt is calcium carbonate. It is clear that their increasing specialisation has caused them to forget irrelevant facts, no matter how fundamental these facts may seem to other scientific

disciplines. Yet the *public* is expected to have this broad knowledge, as is evidenced by the information given by Mintz above. Is it critical that people can define DNA? Does lack of scientific knowledge really matter? The scientists themselves are deeply divided on this issue. Some are "shocked" at the public's ignorance but many recognise, in their own inability to be certain of their answers, that the public cannot be expected to retain facts that are not useful.

Are the scientists, then, lacking in scientific literacy? I suggest that they are not – that their lack of knowledge of a different discipline is not important. What they do have is a very great degree of comfort with science, its processes and its ideas, its methods and its history. They are literate in the best possible way – a way that facilitates further exploration, a broad "feel" for science and an understanding of how to find and use scientific information. These are desirable goals for everyone.